Achmad Zainal Abidin. 2019. Efektivitas Penambahan Nutrisi Dan Formula Konsorsium Bakteri Hidrokarbonoklastik Dalam Biodegradasi Minyak Pelumas Bekas Di Tanah. Tesis di bawah bimbingan: Dr. Ni'matuzahroh dan Dr. Fatimah, S.Si., M.Kes., Departemen Biologi, Fakultas Sains dan Teknologi, Universitas Airlangga, Surabaya.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui (1) toleransi isolat bakteri eksogenus *Acinetobacter* sp. P2-1, *Bacillus subtilis* 3KP, *Micrococcus* sp. LII61, dan *Pseudomonas putida* T1-8 terhadap paparan logam berat Cr^{6+}, Cu^{2+}, Zn^{2+} (tunggal maupun campur) dengan konsentrasi yang berbeda (2) pengaruh variasi perlakuan (pemberian konsorsium bakteri dan variasi nutrisi), waktu inkubasi, dan interaksi keduanya terhadap jumlah total bakteri heterotrofik dan hidrokarbonoklastik (log CFU/g-tanah) (3) pengaruh variasi perlakuan (pemberian konsorsium bakteri dan variasi nutrisi), waktu inkubasi, dan interaksi keduanya terhadap persentase degradasi minyak pelumas bekas (%) (4) kadar rasio C/N dalam bioremediasi tanah tercemar minyak pelumas bekas pada perlakuan terbaik di minggu ke-4 (5) komponen hidrokarbon yang dapat terdegradasi pada perlakuan terbaik di minggu ke-4. Penelitian ini terdiri dari dua tahapan penelitian. Penelitian tahap I adalah uji toleransi bakteri eksogenus terhadap logam berat Cr^{6+}, Cu^{2+}, Zn^{2+} (tunggal maupun campur). Penelitian dilakukan dengan menggunakan metode *streak* pada dua jenis medium padat. Perlakuan terdiri dari tiga faktor. Faktor pertama, yaitu variasi logam berat Cr^{6+}, Cu^{2+}, Zn^{2+} (tunggal maupun campur). Faktor kedua, yaitu variasi konsentrasi logam berat. Faktor ketiga, yaitu variasi jenis medium. Penelitian tahap II adalah uji efektivitas biostimulasi dan bioaugmentasi dalam biodegradasi minyak pelumas bekas di tanah. Perlakuan terdiri dari dua faktor. Faktor pertama, yaitu variasi jenis nutrisi (kompos, serbuk gergajian kayu dan pupuk NPK). Faktor kedua, yaitu waktu inkubasi meliputi minggu ke 0, 1, 2, 3, dan 4. Data hasil toleransi bakteri terhadap logam berat Cr^{6+}, Cu^{2+}, Zn^{2+} (tunggal maupun campur), rasio C/N, dan pengamatan komponen hidrokarbon yang hilang pada perlakuan terbaik setelah dilakukan GC-MS dianalisis secara deskriptif. Data jumlah bakteri heterotrofik (log CFU/g-tanah) dianalisis menggunakan ANOVA dua arah dan uji lanjutan *Duncan*. Data jumlah bakteri hidrokarbonoklastik (Log CFU/g-tanah) dianalisis menggunakan *Brown-Forsyithe* dan uji lanjutan *Games-howel.* Data persentase degradasi (%) dianalisis menggunakan *Kruskall-Wallis* dan uji lanjutan *Mann-Whitney*. Hasil penelitian tahap I menunjukkan *Micrococcus* sp. LII61 merupakan bakteri yang paling toleran terhadap paparan logam berat Cr^{6+}, Cu^{2+}, Zn^{2+} (tunggal maupun campur) dibandingkan tiga bakteri yang lain dengan kemampuan toleransi *Micrococcus* sp. LII61 terhadap logam berat secara berturut-turut yaitu $Zn^{2+} > Cu^{2+} > Cr^{6+}$. Hasil penelitian tahap II menunjukkan bahwa variasi perlakuan (pemberian konsorsium bakteri dan variasi nutrisi), waktu inkubasi, dan interaksi keduanya berpengaruh terhadap jumlah bakteri heterotrofik, hidrokarbonoklastik (Log CFU/g-tanah), persentase degradasi (%), kadar rasio C/N, serta senyawa hidrokarbon yang terkandung dalam tanah

tercemar pelumas bekas. Kadar rasio C/N pada minggu terakhir pada perlakuan terbaik yaitu 25,15. Perlakuan BNG (penambahan konsorsium bakteri, pupuk NPK, serbuk gergaji) pada minggu ke-4 menunjukkan hasil terbaik dengan persentase degradasi mencapai 42,6±4,54%. Komponen hidrokarbon yang mampu terdegradasi adalah hidrokarbon alifatik (*propylamine, isobutylamine, hexanol*), monoaromatik (kelompok *naphtalene*), dan poliaromatik.

Kata Kunci : Minyak pelumas bekas, logam berat, NPK, kompos, serbuk gergaji, konsorsium bakteri, waktu inkubasi.

Achmad Zainal Abidin, 2019 Effectivity of Nutrition and Consortium of Hydrocarbonoclastic Bacteria Amendment in Biodegradation of Used Lubricating Oil in Soil. This thesis was under the supervision of Dr. Ni'matuzahroh and Dr. Fatimah, S.Si., M.Kes., Departement of Biology, Faculty of Science and Technology, Airlangga University, Surabaya

ABSTRACT

This study was aimed to know (1) the tolerance of exogenous bacteria isolates *Acinetobacter* sp. P2-1, *Bacillus subtilis* 3KP, *Micrococcus* sp. LII61, and *Pseudomonas putida* T1-8 against heavy metal Cr^{6+}, Cu^{2+}, Zn^{2+} (single or mixed heavy metal) with different concentrations (2) the effect of treatment variances (consortium and nutrition), incubation time, and the interaction of both variables to heterotropic and hydrocarbonoclastic bacteria total plate counts (log CFU/g-soil) (3) the effect of treatment variance (consortium and nutrition), incubation time, and the interaction of both variables to degradation percentage of used lubricating oil (%) (4) level of C/N ratio in bioremediation of lubricating oil-contaminated soil in the best treatment the 4^{th} week (5) the hydrocarbon component which could be degraded in the best treatment the 4^{th} week. This study consist of two research stages. The first research stage is exogenous bacteria tolerance against heavy metal Cr^{6+}, Cu^{2+}, Zn^{2+} (single or mixed heavy metal). This research was performed using streak method on two kinds of solid medium. The treatment consists of three factors. The first factor was kinds of heavy metal Cr^{6+}, Cu^{2+}, Zn^{2+} (single or mixed heavy metal). The second factor was heavy metal concentration. The third factor was variation of medium. The second research stage is effectivity of biostimulation and bioaugmentation in biodegradation of used lubricating oil in soil. The treatment groups consist of two factors. The first factor was variation of nutrition (compost, sawdust, and NPK fertilizer). The second factor was incubation period includes weeks 0, 1, 2, 3 and 4. Data of bacteria tolerance against heavy metal Cr^{6+}, Cu^{2+}, Zn^{2+} (single or mixed), C/N ratio, and observation of lost hydrocarbon component in the best treatment after GC-MS was analyzed descriptively. Data number of heterotrophic bacteria (log CFU/g-soil) was analyzed using two way-ANOVA followed by Duncan test. Data number of hydrocarbonoclastic bacteria (log CFU/g-soil) was analyzed using Brown-Forsyithe test followed by Games-Howel test. Data of degradation percentage (%) was analyzed using Kruskall-Wallis test followed by Mann-Whitney test. The result of the first research stage showed that *Micrococcus* sp. LII61 had the highest tolerance against exposure of heavy metal Cr^{6+}, Cu^{2+}, Zn^{2+} (single or mixed heavy metal) compare to other three bacterias with ability levels rolerance of *Micrococcus* sp. LII61 in some heavy metals was $Zn^{2+} > Cu^{2+} > Cr^{6+}$ consecutively. The result of the second research stage showed that treatment variation (consortium and nutrition), incubation time, and the interaction of both variables affected the number of heterotrophic and hidrocarbonoclastic bacterias (log CFU/g-soil), percentage of degradation (%), level of C/N ratio and

hidrocarbon compound contained in lubricating oil-contaminated soil. Level of C/N ratio on the last week, on the best treatment was 25,15. BNG treatment (amendment of bacteria consortium, fertilizer NPK, sawdust) at the 4th week showed the best results with the percentage of degradation reached 42,6±4,54%. The component of hydrocarbon compound that capable of being degraded were aliphatic hydrocarbon (*propylamine, isobutylamine, hexanol*), monoaromatic (*naphthalene* group), dan polyaromatics.

Keywords: Used lubricating oil, heavy metal, NPK, compost, sawdust, bacteria consortium, incubation time